EXTENT, SOURCES, AND CONTROL OF POLLUTION FROM MINING ACTIVITIES

by

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Water pollution results to some degree from mining operations throughout the country involving many metallic and non-metallic minerals and commodities. Water quality is affected by active surface and underground mines and mineral preparation activities. Abandoned underground mines, unreclaimed surface mined lands, and refuse and tailings piles that have been discontinued from use may continue to contribute pollutants for many years.

According to the U.S. Department of Interior Publication "Surface Mining and Our Environment" (1967), an estimated 3.2 million acres of land had been disturbed by surface mining activities in the United States prior to January 1, 1965. Mine access roads and exploration activities have affected an additional 320,000 acres. Coal mining has disturbed 41 percent of the total; sand and gravel 26 percent; stone, gold, clay, phosphate, and iron, together, about 28 percent; and all others about 5 percent. About two-thirds of the disturbed acreage requires some remedial attention. About 153,000 additional acres of land were disturbed in 1964 by surface mining, and a comparable amount is being disturbed each year. Surface mining affects water quality primarily through increased amounts of silt and through acid drainage.

The drainage that originates from within underground mines is the principal cause of pollution from such mines. This drainage is frequently acid in the case of coal mines and also in the case of some metal mines where sufficient amounts of sulfide minerals occur in the surrounding rocks. The waste rock or coal refuse extracted during underground mining and the tailings left from mineral processing may be disposed in piles that can be sources of highly mineralized drainage.

By far the most significant water pollution problem from mining is that caused by coal mining in the Appalachian Region coal fields and to a lesser degree the Illinois basin coal fields (Figure 1). The Appalachian coal fields as shown in Figure 1 nearly all fall within the boundaries of the Appalachian Region as it has been defined by Congress. Reference in this paper to Appalachia is to the political region, but for practical purposes statistics given are applicable to the entire Appalachian coal producing area in Figure 1.

The extent of stream pollution from coal mine drainage is greatest in Pennsylvania and West Virginia, and exists to a lesser degree in Ohio, Maryland and eastern Kentucky. Relatively smaller amounts of stream miles are affected in Tennessee, Alabama and Virginia. It has recently been determined that a total 10,500 miles of streams in these Appalachian States are significantly degraded by pollutants from coal mining activities. About 6,700 miles of these streams are continuously degraded below desirable quality levels and the remainder are intermittently affected (Federal Water Pollution Control Administration, 1969).

The primary pollutants in Appalachian streams are the sulfuric acid and iron that result from the oxidation of pyrite (FeS_2) that is associated with the coal. The Sulfuric acid may in turn dissolve other minerals such as manganese, aluminum and calcium. The sulfuric acid, iron and other minerals in mine drainage affect water use in various ways. To many, the most dramatic effects of coal mine drainage pollution are in the destruction of fish and other aquatic life and impairment to stream appearance that often occur. Acid coal mine drainage pollution may affect the use of water for municipal and industrial supply by increasing the costs for equipment and for water treatment. An additional damaging effect is the increased corrosiveness of the polluted water to boats, barges, dams, bridges and other structures built in the streams.

The degree of severity of stream pollution in Appalachia results from a number of sometimes-complex geologic, topographic, and hydrologic factors, but the four principal reasons are considered to be:

1. The extent of mining. About 75 percent of the total cumulative coal production in the United States has been from this area. About 75 percent of the present annual production is from Appalachia. Coal deposits underlie more that 72,000 square miles.

2. The association of relatively large amounts of sulfide minerals with certain coal beds and the concurrent absence of carbonate minerals that could neutralize the acid.

3. The abundant rainfall. The average precipitation is more than 47 inches annually.

4. The fact that many important coal seams are exposed in hillsides above stream-level and water that enters mines in these coal seams drains by gravity into the adjacent streams.

The total number of mines that have been opened in Appalachia is not known. There are presently about 7,000 operating coal mines in the Appalachian Region. Approximately 75 percent of present Appalachian coal production is from underground mines.

Recent field surveys have been made to determine the sources of the coal mine drainage pollution in Appalachian streams. The surveys were

carried out principally in the Allegheny, Monongahela, and Susquehanna River drainage basins, which include about 70 percent of the miles of Appalachian streams polluted by coal mine drainage. A total of 5,570 sources of pollution were located including 405 active and 5,165 abandoned surface and underground mines, refuse piles, and coal preparation plants. The statistical results of these surveys are given in Table 1. The table shows that, within the areas surveyed, 78 percent of the acid pollution originates in inactive or abandoned mines and 22 percent in active mines. Underground mines contribute a total of 71 percent of the acid, abandoned underground mines alone discharge over 50 percent of the acid pollution.

Coal mine drainage pollution similar to that in Appalachia also occurs in the Illinois basin coal fields of eastern Kentucky, southern Indiana and southern Illinois. However, many of the coal mines in the Illinois basin produce little or no water pollution because of the geologic and topographic characteristics of that area. Coal mine drainage pollution occurs in areas of other States, including Missouri, Oklahoma, Kansas, Iowa and Montana.

Acid mine drainage pollution results from the mining of clay and such metals as copper, zinc, lead, iron, and barium. States with streams affected by acid drainage from metal mining operations include, at least, Arkansas, California, Colorado, Maine, Missouri, Montana, Nevada, Oklahoma, South Dakota, Tennessee and Virginia. In acid waters from metal mining operations, such toxic elements as arsenic, lead and copper may be present in concentrations well above desirable limits.

Although acid drainage is the most significant mining pollution problem nationally, silt pollution and other types of chemical pollution also occur. Excess silt pollution or turbidity may result from surface mining, in particular, regardless of the type of commodity extracted. Every state has surface mining and processing of nonmetallic minerals and commodities that causes silt pollution to varying degrees. Placer mining is a specialized form of surface mining that is of special concern in Alaska (Federal Water Pollution Control Administration, 1969-a). Water quality is presently affected by uranium mill tailings piles (Federal Water Pollution Control Administration, 1966) and other uranium mining and processing operations in the Colorado Plateau area and the potential for a greater future problem exists. The surface mining and processing of phosphate has long affected waters in Florida.

This discussion provides a sketch of the extent to which pollution from mining and mineral processing occurs nationally. What should be done to abate such stream pollution?

In my view, although a mining operation may be somewhat physically less consolidated than an industrial operation, it is simply another type of "factory" and can be considered as such for water pollution control purposes. This is even more true of mineral processing operations. Pollution from active mining and mineral processing operations can be handled through proper mining and water handling practices and,

TABLE 1

Statistical Distribution by Number and Acid Contribution of Coal Mine Drainage Sources in the Appalachian Region

Percent of Total Sources	Source Category: Underground Mines	Surface Mines	Combination Surface & Underground Mines	Other Sources	Total Percentages
Active Sources	5.0	1.4	0.4	0.5	7.3
Inactive Sources	53.0	27.0	8.4	4.3	92.7
Total	58.0	28.4	8.8	4.8	100.0
Percent of Net Acidity					
Active Sources	18.8	0.9	1.9	0.4	22.0
Inactive Sources	52.5	11.1	7.3	7.1	78.0
Total	71.3	12.0	9.2	7.5	100.0

if necessary, by treatment of mine drainage and plant process water.

In general, a program for dealing with water pollution from abandoned mines and associated sources consists of the following five phases:

1. An initial survey of stream conditions to locate streams polluted by mine drainage and to determine which watersheds contain the mines that are contributing the drainage.
2. A detailed examination of the watersheds contributing drainage, in a priority order, to locate and characterize the individual mine drainage sources. The objective of this phase is to isolate principal pollution sources in order to focus corrective measures on them.
3. The design of a specific pollution abatement program, by watershed, in priority order based on conditions observed during the detailed inventory work of phase 2.
4. Implementation of the abatement program, again, in a priority order.
5. Monitoring of the implemented program and continuing control over potential new pollution sources.

As has been described, much work has been done toward completion of the first two phases of such a program in the coal mining area of Appalachia. Similar work has been done in smaller problem areas in other parts of the country. The only substantial effort toward a construction program to deal with abandoned mine pollution sources is being undertaken in Pennsylvania, where $150 million has been allocated for this purpose. A brief description of Pennsylvania's program for dealing with pollution from abandoned mines is given in the publication "Pennsylvania's Ten Year Mine Drainage Pollution Abatement Program for Abandoned Mines" (Pennsylvania Department of Health, 1968).

Lack of funding is not, however, the only problem that must be surmounted in abating pollution from abandoned mines. There are significant technical difficulties that must be solved also, particularly in the case of abandoned underground coal mines. New and improved approaches to abating acid coal mine drainage pollution are being investigated under research grants and contracts supported by FWPCA. This research is described elsewhere in the symposium proceedings.

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